OLIVINE AND CA-PHOSPHATE IN THE DIOGENITES MANEGAON AND RODA. K. J. Domanik, L. C. Sideras, and M. J. Drake, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721-0092.

Introduction: The textural relationships between the different primary minerals in igneous rocks provide one of the most fundamental pieces of evidence available for inferring the crystallization history of their parent magmas. Unfortunately, the high degree of brecciation that characterizes most diogenites, along with the low modal abundance and small grain sizes of minerals other than orthopyroxene, combine to make identifying and interpreting such textural relationships extremely difficult in this class of meteorites. A few descriptions of primary igneous contacts between orthopyroxene and chromite, troilite, and to a lesser extent, olivine in diogenites have been provided in the literature (e.g. [1, 2, 3]). In addition to these, in previous work, our research group has characterized several types of igneous contacts between Ca-pyroxene, plagioclase and orthopyroxene in the Bilanga diogenite [4]. We have also described primary igneous inclusions of troilite + kamacite + chromite + Ca-pyroxene +/- Ca-phosphate in orthopyroxene (i.e. Metal/Troilite-Ball inclusions) in the diogenites Bilanga, Manegaon, Johnstown, Roda, Shalka, and Tatahouine [5]. However, for the most part, detailed data on igneous textural relations between minerals other than orthopyroxene in diogenites are still sparse.

Of the diogenite samples that we have examined, the samples of Manegaon and Roda contain by far the most numerous, diverse, and largest examples of primary igneous contacts between silicate and phosphate minerals that we have observed so far. In these two meteorites we have identified 10 different types of mineral contacts (based differences in phase assemblages) that appear to be primary and not significantly influenced by subsequent shock events. In this abstract we describe the contacts in these two meteorites that involve olivine and orthopyroxene (plus other phases). We also describe contacts involving orthopyroxene and Ca-phosphate minerals (both fluor-apatite and REE-bearing whitlockite) as data on the occurrence and compositions of phosphates in diogenites are also relatively rare.

Olivine-Orthopyroxene Contacts in Manegaon: In Manegaon primary igneous contacts between olivine and orthopyroxene are relatively abundant and occur in several textural settings. The majority are found in breccia clasts of various sizes and consist of orthopyroxene + olivine +/- troilite. In addition, a few are present as inclusions of olivine within single large crystals of orthopyroxene (Fig. 1) or as small grains of olivine that are interstitial between large orthopyroxene grains. In these types of contacts, minor amounts of Ca-pyroxene and troilite are also present. The contacts between olivine and orthopyroxene are smooth and regular in shape. The compositions of olivine and orthopyroxene are constant throughout the sample and are more Mg-rich than is observed in most other diogenites [1]. Average olivine compositions are (mg# 78; Fo_{78}, Fa_{22}; FeO/MnO 48) (mg# calculated as Mg/Mg+Fe cations pfu * 100). Average orthopyroxene compositions are (mg# 80; En_{78}, Fs_{20}, Wo_2; FeO/MnO 27). Ca-pyroxene (when present) averaged (mg# 87; En_{47}, Fs_7, Wo_{45}; FeO/MnO 21). Electron microprobe line scans across olivine-orthopyroxene contacts indicates that the minor elements Ca, Cr, and Al in orthopyroxene increase in concentration with distance from the boundary with olivine.

Olivine - Orthopyroxene Contacts in Roda: One contact between olivine and orthopyroxene was observed in Roda which differs from the contacts found in Manegaon in phase assemblage, texture, and composition (Fig. 2). The contact occurs in a clast and consists of roughly equal amounts of olivine, orthopyroxene, and Ca-pyroxene (+troilite). The boundaries between olivine and both orthopyroxene and Ca-pyroxene are irregular in shape whereas the boundary between orthopyroxene and clinopyroxene is almost linear. Average olivine composition is (mg# 73; Fo_{73}, Fa_{27}; FeO/MnO 54), average orthopyroxene (mg# 77; En_{76}, Fs_{22}, Wo 1; FeO/MnO 31), Ca-pyroxene (mg# 85; En_{46}, Fs_8, Wo_{45}; FeO/MnO 24). Unlike Manegaon, the Opx and Cpx in this contact appear to be slightly more Mg-rich than the average observed for these minerals in all occurrences in Roda (Opx: mg# 75, Cpx Mg# 83).

An olivine-orthopyroxene contact in Roda has previously been described by [2] with olivine mg# 72.5, orthopyroxene mg# 77, which are similar to those observed in this study.

Ca-Phosphate - Orthopyroxene Contacts: Primary igneous contacts between orthopyroxene and Ca-phosphate minerals are observed in both Manegaon and Roda. These occur as irregular to subhedral contacts in breccia fragments and as small inclusions with orthopyroxene grains that are usually associated with Ca-pyroxene and/or MT-Ball inclusions. In the sections we examined, fluor-apatite is the predominant phosphate in Manegaon, (10 analyzed grains; 9 fluor-apatite, 1 low-REE whitlockite). Fluor-apatite is also the only phosphate observed in Shalka, Johnstown, and LAP 02216, but in much lower abundance than in

Manegaon and Roda. REE-bearing whitlockite is the major phosphate observed in Roda, (17 analyzed grains; 15 REE-whitlockite, 2 fluor-apatite). Average compositions of the two minerals are given in Table 1. In one case in Roda, inclusions of both whitlockite and fluor-apatite are observed within the same grain of orthopyroxene. Two occurrences of whitlockite in Roda were associated with shocked pools of silica + Ca-pyroxene within orthopyroxene grains that are similar in some respects to those previously described in Roda and in Bilanga by [2] and [4] respectively. The analysis of the phosphate in Roda published by [2] is very similar to the average analyses we obtain from a variety of textural settings in Roda. However, the majority of phosphates in both Roda and Manegaon appear to be of igneous origin and unrelated to glass, silica, or obviously shocked material.

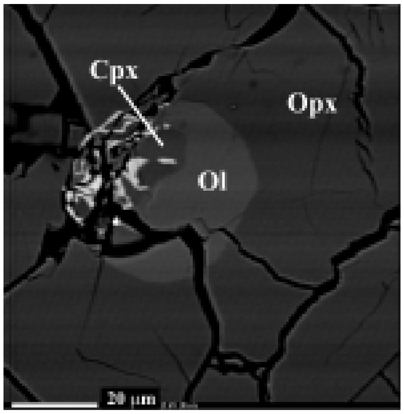

Fig 1: Olivine inclusion within a large orthopyroxene grain in Manegaon. Ca-pyroxene and chromite (light) appear to be the result of later, (Type II of [4]) exsolution processes.

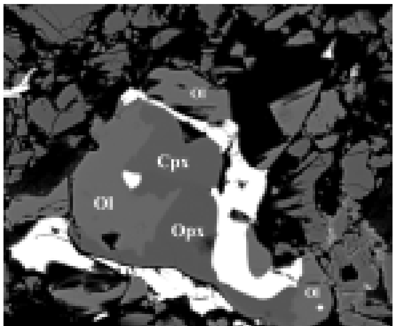

Fig 2: Clast containing intergrown olivine, orthopyroxene, Ca-pyroxene, and troilite (bright) in Roda.

	F-Apatite Manegaon	Whitlockite Roda
F	3.71	0.00
P2O5	40.82	42.23
CaO	55.36	41.98
SiO2	0.27	0.23
MgO	n.a.	3.52
FeO	0.52	0.96
Na2O	0.01	0.79
Y2O3	0.00	0.67
La2O3	0.07	1.20
Ce2O3	0.06	2.64
Nd2O3	n.a.	1.62
Pr2O3	n.a	0.45
Other	0.09	0.44
Total	99.39	96.73

Table 1: Average of selected phosphate analyses in Manegaon and Roda. n.a. = Not Analyzed

Conclusions: A number of workers have suggested, based on minor and trace element trends in diogenite orthopyroxene, that both Manegaon and Roda may not be part of the main petrogenetic sequence or even derived from the same parental magmas as the majority diogenites (e.g. [2, 6]). Orthopyroxenes in both, but particularly in Roda, exhibit an exceptionally wide range of concentrations of incompatible trace elements such as Y, Yb, Zr, Ti, and Al compared with other diogenites. It has also been suggested that Roda may represent a polymict breccia (e.g. [7]).

Detailed examination of the textural relations between minor phases and orthopyroxene indicates that Manegaon and Roda are unusual. Both meteorites display a more orthocumulate texture than is found in most diogenites. Minor phases achieve greater size and display better developed igneous contacts with orthopyroxene than is observed in other samples. The greater abundance of phosphates in both samples suggests longer contact with the melt of the main magma chamber resulting in a more evolved phase assemblage. The presence of REE-bearing whitlockite in a variety of textural settings in Roda, and its near absence in the other diogenites, suggests that the intercumulate melt in Roda reached a higher degree of fractionation. The wide spatial distribution of phosphate (and other minor phases) in Roda suggests a more thorough mixing process during brecciation than we observe in other diogenites. However, textural evidence as to whether Roda is a polymict breccia is inconclusive at this point.

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[1] Mittlefehldt et al. (1998) *Planetary Materials*, (J. J. Papike ed.). [2] Mittlefehldt (1994) *Geochim. Cosmochim Acta*, 58, 1537-1552. [3] Gooley and Moore (1976). *Am. Mineral*. 61, 373-378. [4] Domanik et al. (2004) *Meteor. and Planet. .Sci.*, 39, 567-579. [5] Sideras et al. (2004) *LPS XXXV*, abstr. no. 1752. [6] Fowler et al. (1995) *Geochim. Cosmochim Acta*, 59, 3071-3084. [7] Fowler et al. (1997) *LPS XXVIII*, 377-378.